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Chet Poslusny, Senior Project Manager
Standardization Project Directorate
Associate Directorate for Advanced Reactors
and License Renewal
Office of Nuclear Reactor Regulation

Subject: Submittal Supporting Accelerated ABWR Schedule - **Response to Open Item F19.3.3.2.1-1 and F19.3.3.2.1-2**

Dear Chet:

Enclosed are SSAR markups addressing the subject Open Items. These markups justify that (1) RIP impeller and shaft replacement can take place with fuel in the vessel and (2) removal of the blade and the drive of the same assembly can be conducted.

Please provide a copy of this transmittal to Mark Reinhart.

Sincerely,

Jack Fox

Jack Fox
Advanced Reactor Programs

cc: Alan Beard (GE)
Norman Fletcher (DOE)
Dick Ose (GE)
Joe Quirk (CE)
Dick Pobertshaw (GE)

JNF94-003

4.6.1.2.1 Fine Motion Control Rod Drive Mechanism

The FMCRD used for positioning the control rod in the reactor core is a mechanical/hydraulic actuated mechanism (Figures 4.6-1, 4.6-2 and 4.6-3). An electric motor-driven ball-nut and spindle assembly is capable of positioning the drive at a minimum of 18.3 mm increments. Hydraulic pressure is used for scrams. The FMCRD penetrates the bottom head of the reactor pressure vessel. The FMCRD does not interfere with refueling and is operative even when the head is removed from the reactor vessel.

The fine motion capability is achieved with a ball-nut and spindle arrangement driven by an electric motor. The ball-nut is keyed to the guide tube (roller key) to prevent its rotation and traverses axially as the spindle rotates. A hollow piston rests on the ball-nut and upward motion of the ball-nut drives this piston and the control rod into the core. The weight of the control rod keeps the hollow piston and ball-nut in contact during withdrawal.

A single HCU powers the scram action of two FMCRDs. Upon scram valve initiation, high pressure nitrogen from the HCU raises the piston within the accumulator, forcing water through the scram piping. This water is directed to each FMCRD connected to the HCU. Inside each FMCRD, high-pressure water lifts the hollow piston off the ball-nut and drives the control rod into the core. A spring washer buffer assembly stops the hollow piston at the end of its stroke. Departure from the ball-nut releases spring-loaded latches in the hollow piston that engage slots in the guide tube. These latches support the control rod in the inserted position. The control rod cannot be withdrawn until the ball-nut is driven up and engaged with the hollow piston. Stationary fingers on the ball-nut then cam the latches out of the slots and hold them in the retracted position. A scram action is complete when every FMCRD has reached their fully inserted position.

The use of the FMCRD mechanisms in the CRD System provides several features which enhance both the system reliability and plant operations. Some of these features are listed and discussed briefly as follows:

(1) Diverse Means of Rod Insertion

The FMCRDs can be inserted either hydraulically or electrically. In response to a scram signal, the FMCRD is inserted hydraulically via the stored energy in the scram accumulators. A signal is also given simultaneously to insert the FMCRD electrically via its motor drive. This diversity provides a high degree of assurance of rod insertion on demand.

(2) Absence of FMCRD Piston Seals

~~The FMCRD pistons have no seals and, thus, do not require maintenance.~~

REPLACE WITH ATTACHMENT A

ATTACHMENT A:

The FMCRD pistons have no seals that require periodic drive removal for maintenance; the FMCRD internals can remain in place for their full design life. Only a sample of two or three complete FMCRDs are planned to be removed for inspection each refueling outage to document drive condition. This is an order of magnitude reduction compared to previous BWR product lines in which 20 to 30 complete drives are removed for piston seal replacement each refueling outage.

4.6.2.3.3.2 Control Rod Drop Prevention

Control rod drop is prevented by the following features:

(1) Two redundant Class 1E switches in the FMCRD sense separation of the hollow piston, which positions the control rod, from the ball-nut. These switches sense either separation of the piston from the nut or separation of the control rod from the piston, and block further lowering of the nut, thereby preventing drop of either the control rod or the control rod and hollow piston as an assembly (See Subsection 4.6.1.2.2.6 for further details).

(2) Two redundant spring-loaded latches on the hollow piston open to engage in openings in the guide tube within the FMCRD to catch the hollow piston if separation from the ball-nut were to occur. These latches open to support the hollow piston (and control rod) following every scram until the ball-nut is run-in to provide the normal support for the hollow piston (and control rod).

(3) The control-rod to hollow-piston coupling is a bayonet type coupling. Coupling is verified by pull test for the control rod upon initial coupling at refueling and again each time an attempt is made to drive beyond the "full out" position during reactor operation. The control rod can only be uncoupled from the FMCRD by relative rotation, which is not possible during operation. The control rod cannot rotate, since it is always constrained between four fuel assemblies, and the hollow piston/CRD bayonet coupling cannot rotate, since the hollow piston has rollers which operate in a track within the FMCRD. Only structural failure would permit or result in control rod to FMCRD uncoupling, which, in turn, could only result in rod drop if the redundant switches failed to sense separation. In such failure scenarios, the rate of rod drop may exceed acceptable reactivity addition rates; however, the number of failures involved in the scenario are so numerous that the probability of occurrence for the event is low enough to be categorized as incredible.

4.6.2.3.4 ← ADD NEW PARAGRAPH PER ATTACHMENT B

4.6.3 Testing and Verification of the CRDs

4.6.3.1 Development Tests

The initial development of the FMCRD involved testing of a prototype based on a European drive design. Testing of this prototype included more than 600 scrams and 67,000 motor-driven cycles. A subsequent prototype was developed for installation in an operating BWR for the purpose of demonstrating FMCRD performance under actual BWR operating conditions. This in-plant FMCRD prototype was tested extensively prior to installation at the operating plant, including over 500 scrams and 63,000 step cycles. The inplant FMCRD was installed at LaSalle Unit 2, where it was tested for one complete operating cycle.

ATTACHMENT B:

4.6.2.3.4 CRD Maintenance

The procedure for removal of the FMCRD for maintenance or replacement is similar to previous BWR product lines. The control rod is first withdrawn until it backseats onto the control rod guide tube. This metal-to-metal contact provides the seal that prevents draining of reactor water when the FMCRD is subsequently lowered out of the CRD housing. The control rod normally remains in this backseated condition at all times with the FMCRD out; however, in the unlikely event it also has to be removed, a temporary blind flange is first installed on the end of the CRD housing to prevent draining of reactor water.

If the operator inadvertently removes the control rod after FMCRD is out without first installing the temporary blind flange, or conversely, inadvertently removes the FMCRD after first removing the control rod, an unisolable opening in the bottom of the reactor will be created, resulting in drainage of reactor water. The possibility of inadvertent reactor draindown by this means is considered remote for the following reasons:

(1) Procedural controls similar to those of current BWRs will provide the primary means for prevention. Current BWR operating experience demonstrates this to be an acceptable approach. There has been no instance of an inadvertent draindown of reactor water due to simultaneous CRD and control rod removal.

(2) During drive removal operations, personnel will be required to monitor under the RPV for water leakage out of the CRD housing. Abnormal or excessive leakage occurring after only a partial lowering of the FMCRD within its housing will indicate the absence of the full metal-to-metal seal between the control rod and control rod guide tube required for full drive removal. In this event, the FMCRD can then be raised back into its installed position to stop the leakage and allow corrective action.

A Failure Modes and Effects Analysis (FMEA) of the RIP is presented in Appendix 15B.

REPLACED WITH ATTACH. A

RIP maintenance during reactor shutdown requires a temporary plug be installed in the RIP diffuser when the RIP impeller, shaft and motor are temporarily removed. The temporary RIP diffuser plug is designed so it can not be removed unless the RIP motor housing bottom cover is in place.

5.4.1.6 Inspection and Testing

Quality control methods are used during fabrication and assembly of the RRS to assure that design specifications are met (inspection and testing procedures are described in Chapter 3). The RRS is thoroughly cleaned and flushed before fuel is loaded initially.

During the pre-operational test program, the RRS is hydrostatically tested at 125% reactor vessel design pressure. Preoperational tests on the RRS also include checking operation of the pumps and flow control system, as discussed in Chapter 14.

During the startup test program, horizontal and vertical motion of the RIP motor casing is observed. RIP motor acoustic monitoring is provided.

Nuclear system responses to recirculation pump trips at rated temperatures and pressure are evaluated during the startup tests, and plant power response to recirculation flow control is determined.

5.4.2 Steam Generators (PWR)

Not applicable to this BWR.

5.4.3 Reactor Coolant Piping

Since the RIPs are located inside the RPV, there is no major external reactor coolant piping connected to the ABWR pressure vessel.

5.4.4 Main Steamline Flow Restrictors

5.4.4.1 Safety Design Bases

The main steamline flow restrictors were designed to:

(1) Limit the loss of coolant from the reactor vessel following a steamline rupture outside the containment to the extent that the reactor vessel water level remains high enough to provide cooling within the time required to close the main steamline isolation valves.

(2) Limit the maximum pressure differences expected across the reactor internal components following complete severance of a main steamline.

ATTACH. A

During normal RIP maintenance, the following sequence is performed:

1. The RIP motor, lower cover and impeller-shaft are unbolted and lowered until the shaft backseats on the top of the stretch tube shown in Fig. 5.4-1.

2. The secondary inflatable seal is pressurized and the motor housing is drained.

3. The motor and cover are removed from the motor housing.

4. A maintenance cover is bolted to the bottom of the motor housing and the housing is pressurized with water until equilibrium with the RPV static head pressure is reached. The secondary seal is then depressurized.

5. After it is confirmed that the bottom cover is properly installed, the impeller-shaft is lifted out of the RPV and a maintenance plug is installed on the stretch tube top. During the shaft lifting or maintenance plug removal step, personnel will monitor visually for leakage down out of the housing. The requirement for the COL applicant administrative procedure is described in 5.4.15.4.

The refueling platform auxiliary hoist, used for handling the impeller-shaft, is equipped with a load cell interlock which interrupts the hoisting power if the load exceeds the setpoint. The setpoint is less than the sum of the impeller-shaft weight and the hydrostatic head on the impeller.

The maintenance RIP diffuser plug is designed with a break-away lifting lug so it can not be removed unless the RIP motor housing permanent or maintenance bottom cover is bolted in place and the housing pressure is in equilibrium with the RPV static pressure.

6. With the maintenance RIP diffuser plug in place, the motor housing is again drained and the maintenance bottom cover is removed. With the impeller shaft removed, maintenance on the secondary seal and stretch tube inspection is performed.

7. The bottom maintenance cover is again installed and the housing refilled and pressurized.

8. The maintenance top plug is removed and reassembly of the impeller-shaft-motor is completed in reverse order of 1 - 6 above including housing draining and filling."

In summary, the auxiliary hoist load cell prevents lifting the impeller if a bottom cover is not installed. The break-away lifting lug on the maintenance plug prevents lifting the plug if the bottom cover is not installed. In addition, undervessel leakage monitoring is required during these operations. Therefore, the possibility of an inadvertent RPV drain down is extremely remote.

5.4.14.4 Inspection and Testing

After completion of the installation of a support system, all hangers and snubbers are to be visually examined to assure that they are in correct adjustment to their cold setting position. Upon hot startup operations (Subsection 3.9.2.1.2), thermal growth will be observed to confirm that spring-type hangers will function properly between their hot and cold setting positions. Final adjustment capability is provided on all hangers and snubbers. Weld inspections and standards are to be in accordance with ASME Code Section III. Welder qualifications and welding procedures are in accordance with ASME Code Section IX and NF-4300 of ASME Code Section III.

5.4.15 COL License Information

5.4.15.1 Testing of Main Steam Isolation Valves

COL applicants will test the main steam isolation valves in actual operating conditions (70 kg/cm^{2}g, 286°C).

5.4.15.2 Analyses of 8-Hour RCIC Capability

COL applicants will provide the analyses for the as-built facility to demonstrate RCIC 8-hour capability (Subsection 5.4.6.1).

5.4.15.3 ACIWA Flow Reduction

The COL applicant shall perform an analysis to determine if a flow reduction device is required as specified in Subsection 5.4.7.1.1.10.3.

5.4.16 References

5.4-1 *Design and Performance of General Electric Boiling Water Reactor Main Steamline Isolation Valves,* General Electric Co., Atomic Power Equipment Department, March 1969 (APED-5750).

"15.4.15.4 RIP and FMCRD Maintenance Personnel

The COL applicant shall provide RIP and FMCRD maintenance procedures in accordance with the sequence of steps listed in 5.4.1.5 and 4.6.2.3.4 which require personnel to monitor, under the RPV, during RIP impeller-shaft, RIP maintenance plug removal, FMCRD or CR removal for water leakage out of the RIP/motor or FMCRD housing."